

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in this application.

Listing of Claims:

Claim 1 (Previously Amended): An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

a fluid conduit configured for flow of fluid therethrough, the fluid conduit having an internal surface having at least a selected one of inwardly and outwardly extending projections formed thereon which induces turbulence in fluid flow in the conduit; and

a piezoelectric material attached to the conduit, the piezoelectric material producing electricity in response to pressure fluctuations in the conduit.

Claim 2 (Original): The generator according to Claim 1, wherein the pressure fluctuations are due to fluid flowing through the conduit.

Claim 3 (Original): The generator according to Claim 1, wherein the fluid conduit is generally tubular.

Claim 4 (Original): The generator according to Claim 3, wherein the conduit is connectable in a tubular string positioned in the subterranean well.

Claim 5 (Original): The generator according to Claim 1, wherein the fluid conduit includes a reduced thickness portion thereof, the piezoelectric material being attached proximate the reduced thickness portion.

Claim 6 (Previously Amended): An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

- a fluid conduit configured for flow of fluid therethrough; and
- a piezoelectric material attached to the conduit, the piezoelectric material producing electricity in response to pressure fluctuations in the conduit,

- the fluid conduit including a reduced thickness portion thereof, the piezoelectric material being attached proximate the reduced thickness portion,

- the reduced thickness portion having an increased degree of flexing, in response to the pressure fluctuations in the conduit, relative to the remainder of the conduit.

Claim 7 (Original): The generator according to Claim 1, wherein the piezoelectric material is attached to an external surface of the fluid conduit.

Claim 8 (Canceled)

Claim 9 (Currently Amended): An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

a fluid conduit configured for flow of fluid therethrough; and

a piezoelectric material attached to the conduit, the piezoelectric material producing electricity in response to pressure fluctuations in the conduit,

the fluid conduit ~~being helically shaped~~ having a helical shape operative to induce turbulence in fluid flowing through the fluid conduit.

Claim 10 (Previously Amended): An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

a fluid conduit configured for flow of fluid therethrough; and

a piezoelectric material attached to the conduit, the piezoelectric material producing electricity in response to pressure fluctuations in the conduit,

the fluid conduit having a recess internally formed thereon, the recess inducing turbulence in fluid flow through the fluid conduit.

Claim 11 (Original): The generator according to Claim 10, wherein the recess extends generally helically on the fluid conduit.

Claims 12-13 (Canceled)

Claim 14 (Previously Amended): (Amended) A method of producing power in a subterranean well, the method comprising the steps of:

attaching a piezoelectric material to a reduced thickness portion of a fluid conduit;

interconnecting the fluid conduit in a tubular string;

positioning the tubular string in the well; and

flowing fluid through the fluid conduit, the piezoelectric material producing electricity in response to flexing of the reduced thickness portion created by the flowing of fluid through the conduit,

the reduced thickness portion having an increased degree of flexing, in response to the pressure fluctuations in the conduit, relative to the remainder of the conduit.

Claim 15 (Original): The method according to Claim 14, wherein the attaching step further comprises attaching the piezoelectric material externally to the fluid conduit.

Claims 16-17(Canceled)

Claim 18 (Original): The method according to Claim 14, wherein the flowing step further comprises inducing turbulence in the fluid flowing through the fluid conduit.

Claim 19 (Previously Amended): A method of producing power in a subterranean well, the method comprising the steps of:

attaching a piezoelectric material to a fluid conduit;

interconnecting the fluid conduit in a tubular string;

positioning the tubular string in the well; and

flowing fluid through the fluid conduit, the piezoelectric material producing electricity in response to the flowing of fluid through the conduit,

the flowing step further comprising inducing turbulence in the fluid flowing through the fluid conduit, the inducing turbulence step

further comprising shaping the fluid conduit in a manner increasing turbulence in the fluid flowing through the fluid conduit.

Claim 20 (Original): The method according to Claim 19, wherein the shaping step further comprises helically forming the fluid conduit.

Claim 21 (Original): The method according to Claim 19, wherein the shaping step further comprises forming a recess internally on the fluid conduit.

Claim 22 (Original): The method according to Claim 21, wherein the forming step further comprises forming the recess helically on the fluid conduit.

Claim 23 (Original): An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

- an outer housing;

- a mass reciprocally disposed relative to the housing;

- a piezoelectric material; and

- a bias member positioned between the mass and the piezoelectric material,

pressure fluctuations in the housing causing the mass to displace and thereby induce strain in the piezoelectric material via the bias member.

Claim 24 (Original): The generator according to Claim 23, wherein the pressure fluctuations are due to fluid flowing through the housing.

Claim 25 (Original): The generator according to Claim 23, further comprising a fluid conduit extending in the outer housing, the mass, bias member and piezoelectric material being externally positioned relative to the fluid conduit.

Claim 26 (Original): The generator according to Claim 25, wherein the mass, bias member and piezoelectric material are disposed in a chamber formed between the fluid conduit and the outer housing.

Claim 27 (Original): The generator according to Claim 25, wherein the fluid conduit is plugged, fluid flow therethrough being bypassed to a chamber formed between the outer housing and the fluid conduit.

Claim 28 (Original): The generator according to Claim 23, wherein a shape of a fluid conduit disposed within the outer housing induces turbulence in fluid flow through the fluid conduit.

Claim 29 (Original): The generator according to Claim 28, wherein the fluid conduit shape is helical.

Claim 30 (Original): The generator according to Claim 28, wherein the fluid conduit shape includes a recess formed on the fluid conduit.

Claim 31 (Original): The generator according to Claim 30, wherein the recess extends helically on the fluid conduit.

Claim 32 (Original): The generator according to Claim 28, wherein the fluid conduit shape includes a protrusion formed on the fluid conduit.

Claim 33 (Original): The generator according to Claim 32, wherein the protrusion extends helically on the fluid conduit.

Claim 34 (Original): The generator according to Claim 23, wherein fluid flowing through the outer housing also flows through a fluid conduit disposed within the outer housing.

Claim 35 (Original): The generator according to Claim 34, further comprising a flow restriction in the fluid conduit, the flow restriction forcing at least a portion of the fluid flowing through the fluid conduit to flow between the fluid conduit and the outer housing.

Claim 36 (Original): The generator according to Claim 35, wherein the flow restriction prevents fluid flow directly through the fluid conduit.

Claim 37 (Original): A method of producing power in a subterranean well, the method comprising the steps of:

interconnecting an outer housing in a tubular string;

positioning the tubular string in the subterranean well; and

flowing fluid through the outer housing, thereby causing a mass to displace within the housing and induce strain in a piezoelectric material via a bias member positioned between the mass and the piezoelectric material.

Claim 38 (Original): The method according to Claim 37, wherein the flowing fluid step further comprises flowing fluid through a fluid conduit extending in the outer housing, the mass, bias member and piezoelectric material being externally positioned relative to the fluid conduit.

Claim 39 (Original): The method according to Claim 38, wherein in the flowing fluid step, the mass, bias member and piezoelectric material are disposed in a chamber formed between the fluid conduit and the outer housing.

Claim 40 (Original): The method according to Claim 38, wherein in the flowing fluid step, the fluid conduit is plugged, fluid flow therethrough being bypassed to a chamber formed between the outer housing and the fluid conduit.

Claim 41 (Original): The method according to Claim 37, wherein in the flowing fluid step, a shape of a fluid conduit disposed within the outer housing induces turbulence in fluid flow therethrough.

Claim 42 (Original): The method according to Claim 41, wherein the fluid conduit shape is helical.

Claim 43 (Original): The method according to Claim 41, wherein the fluid conduit shape includes a recess formed on the fluid conduit.

Claim 44 (Original): The method according to Claim 43, wherein the recess extends helically on the fluid conduit.

Claim 45 (Original): The method according to Claim 41, wherein the fluid conduit shape includes a protrusion formed on the fluid conduit.

Claim 46 (Original): The method according to Claim 45, wherein the protrusion extends helically on the fluid conduit.

Claim 47 (Original): The method according to Claim 37, wherein in the flowing fluid step, the fluid flowing through the outer housing also flows through a fluid conduit disposed within the outer housing.

Claim 48 (Original): The method according to Claim 47, wherein in the flowing fluid step, a flow restriction in the fluid conduit forces at least a portion of the fluid flowing through the fluid conduit to flow between the fluid conduit and the outer housing.

Claim 49 (Original): The method according to Claim 48, wherein the flow restriction prevents fluid flow directly through the fluid conduit.

Claims 50-56 (Canceled)

Claim 57 (Currently Amended): ~~The generator according to Claim 50,~~
wherein An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit configured for flow of fluid therethrough;

a fluid chamber in fluid communication with the fluid conduit, the
chamber vibrating in response to pressure fluctuations in the fluid
conduit; and

a piezoelectric material attached to the fluid chamber, the
piezoelectric material producing electricity in response to the fluid
chamber vibration, the piezoelectric material is being attached to the fluid
conduit.

Claim 58 (Currently Amended): ~~The generator according to Claim 50,~~
~~wherein~~ An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit configured for flow of fluid therethrough;

a fluid chamber in fluid communication with the fluid conduit, the
chamber vibrating in response to pressure fluctuations in the fluid
conduit; and

a piezoelectric material attached to the fluid chamber, the
piezoelectric material producing electricity in response to the fluid
chamber vibration,

the fluid conduit is being shaped so that it induces turbulence
in fluid flow therethrough.

Claim 59 (Currently Amended) ~~The generator according to Claim 50,~~
~~wherein~~ An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit configured for flow of fluid therethrough;

a fluid chamber in fluid communication with the fluid conduit, the
chamber vibrating in response to pressure fluctuations in the fluid
conduit; and

a piezoelectric material attached to the fluid chamber, the
piezoelectric material producing electricity in response to the fluid
chamber vibration,

the fluid conduit is being helically shaped.

Claim 60 (Currently Amended) ~~The generator according to Claim 50, wherein~~ An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

a fluid conduit configured for flow of fluid therethrough;

a fluid chamber in fluid communication with the fluid conduit, the chamber vibrating in response to pressure fluctuations in the fluid conduit; and

a piezoelectric material attached to the fluid chamber, the piezoelectric material producing electricity in response to the fluid chamber vibration,

the fluid conduit ~~has~~ having a recess internally formed thereon, the recess inducing turbulence in fluid flow through the fluid conduit.

Claim 61 (Original) The generator according to Claim 60, wherein the recess extends generally helically on the fluid conduit.

Claim 62 (Canceled)

Claim 63 (Currently Amended) ~~The method according to Claim 62, wherein~~ A method of producing power in a subterranean well, the method comprising the steps of:

interconnecting a fluid conduit in a tubular string;

positioning the tubular string in the subterranean well;

flowing fluid through the fluid conduit;

vibrating a fluid chamber in fluid communication with the fluid conduit in response to the flowing fluid step; and

producing electricity from a piezoelectric material in response to the vibrating step,

the vibrating step further ~~comprises~~ comprising vibrating a membrane of the fluid chamber, the piezoelectric material being attached to the membrane.

Claim 64 (Currently Amended): ~~The method according to Claim 62, wherein~~ A method of producing power in a subterranean well, the method comprising the steps of:

interconnecting a fluid conduit in a tubular string;

positioning the tubular string in the subterranean well;

flowing fluid through the fluid conduit;

vibrating a fluid chamber in fluid communication with the fluid conduit in response to the flowing fluid step; and

producing electricity from a piezoelectric material in response to the vibrating step,

in the vibrating step, the fluid chamber is being formed between the fluid conduit and an outer housing.

Claim 65 (Original): The method according to Claim 64, wherein in the producing electricity step, the piezoelectric material is attached to the outer housing.

Claim 66 (Currently Amended): ~~The method according to Claim 62,~~
~~wherein~~ A method of producing power in a subterranean well, the
method comprising the steps of:

interconnecting a fluid conduit in a tubular string;

positioning the tubular string in the subterranean well;

flowing fluid through the fluid conduit;

vibrating a fluid chamber in fluid communication with the fluid
conduit in response to the flowing fluid step; and

producing electricity from a piezoelectric material in response to
the vibrating step,

in the producing electricity step, the piezoelectric material is
being attached to a piston bounding a portion of the fluid chamber.

Claim 67 (Original): The method according to Claim 66, further
comprising the step of displacing the piston to thereby optimize vibration
of the fluid chamber in response to fluid flow through the fluid conduit.

Claim 68 (Currently Amended) ~~The method according to Claim 62,~~
~~wherein~~ A method of producing power in a subterranean well, the
method comprising the steps of:

interconnecting a fluid conduit in a tubular string;

positioning the tubular string in the subterranean well;

flowing fluid through the fluid conduit;

vibrating a fluid chamber in fluid communication with the fluid
conduit in response to the flowing fluid step; and

producing electricity from a piezoelectric material in response to the vibrating step,

in the producing electricity step, the piezoelectric material is being attached to the fluid conduit.

Claim 69 (Currently Amended): ~~The method according to Claim 62, wherein~~ A method of producing power in a subterranean well, the method comprising the steps of:

interconnecting a fluid conduit in a tubular string;

positioning the tubular string in the subterranean well;

flowing fluid through the fluid conduit;

vibrating a fluid chamber in fluid communication with the fluid conduit in response to the flowing fluid step; and

producing electricity from a piezoelectric material in response to the vibrating step,

the flowing step further comprises comprising inducing turbulence in the fluid flowing through the fluid conduit.

Claim 70 (Original): The method according to Claim 69, wherein the inducing turbulence step further comprises shaping the fluid conduit in a manner increasing turbulence in the fluid flowing through the fluid conduit.

Claim 71 (Original): The method according to Claim 70, wherein the shaping step further comprises helically forming the fluid conduit.

Claim 72 (Original): The method according to Claim 70, wherein the shaping step further comprises forming a recess internally on the fluid conduit.

Claim 73 (Original): The method according to Claim 72, wherein the forming step further comprises forming the recess helically on the fluid conduit.

Claim 74 (Canceled)

Claim 75 (Currently Amended): ~~The generator according to Claim 74,~~
~~wherein~~ An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit having a flow passage for flow of fluid therethrough;

a member extending into the flow passage, the member vibrating in
response to fluid flow through the fluid conduit; and

a piezoelectric material producing electricity in response to
vibration of the member,

the member ~~extends~~ extending generally transversely relative
to the flow passage.

Claim 76 (Currently Amended): ~~The generator according to Claim 74,~~
~~wherein~~ An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit having a flow passage for flow of fluid therethrough;

a member extending into the flow passage, the member vibrating in
response to fluid flow through the fluid conduit; and

a piezoelectric material producing electricity in response to
vibration of the member,

the piezoelectric material ~~supports~~ supporting the member in
position relative to the fluid conduit.

Claim 77 (Original): The generator according to Claim 76, wherein the
piezoelectric material encircles the member.

Claim 78 (Original): The generator according to Claim 76, wherein the
member extends into a recess formed internally on the fluid conduit.

Claim 79 (Original): The generator according to Claim 78, wherein the
piezoelectric material is disposed in the recess between the member and
the fluid conduit.

Claim 80 (Currently Amended): ~~The generator according to Claim 74,~~
~~wherein~~ An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit having a flow passage for flow of fluid therethrough;

a member extending into the flow passage, the member vibrating in
response to fluid flow through the fluid conduit; and

a piezoelectric material producing electricity in response to
vibration of the member,

the fluid conduit further ~~has~~ having a protrusion extending
inwardly into the flow passage, the protrusion inducing turbulence in fluid
flow through the flow passage, thereby increasing vibration of the
member.

Claim 81 (Canceled)

Claim 82 (Currently Amended): ~~The method according to Claim 81,~~
~~wherein~~ A method of producing power in a subterranean well, the
method comprising the steps of:

interconnecting in a tubular string a fluid conduit having a flow
passage;

positioning the tubular string in the subterranean well;

flowing fluid through the flow passage;

vibrating a member extending into the flow passage in response to
the flowing fluid step; and

producing electricity from a piezoelectric material in response to
the member vibrating step,

the flowing step further ~~comprises~~ comprising flowing fluid transversely across the member.

Claim 83 (Currently Amended): ~~The method according to Claim 81, wherein~~ A method of producing power in a subterranean well, the method comprising the steps of:

interconnecting in a tubular string a fluid conduit having a flow passage;

positioning the tubular string in the subterranean well;

flowing fluid through the flow passage;

vibrating a member extending into the flow passage in response to the flowing fluid step; and

producing electricity from a piezoelectric material in response to the member vibrating step,

the producing electricity step further ~~comprises~~ comprising supporting the member relative to the fluid conduit utilizing the piezoelectric material.

Claim 84 (Original): The method according to Claim 83, wherein the supporting step further comprises encircling the member with the piezoelectric material.

Claim 85 (Original): The method according to Claim 83, wherein the supporting step further comprises positioning the piezoelectric material between the member and the fluid conduit in a recess formed internally on the fluid conduit.

Claim 86 (Currently Amended): ~~The method according to Claim 81, further comprising the step of~~ A method of producing power in a subterranean well, the method comprising the steps of:

interconnecting in a tubular string a fluid conduit having a flow passage;

positioning the tubular string in the subterranean well;

flowing fluid through the flow passage;

vibrating a member extending into the flow passage in response to the flowing fluid step;

producing electricity from a piezoelectric material in response to the member vibrating step; and

inducing turbulence in the flow passage upstream of the member, thereby increasing vibration of the member in the member vibrating step.

Claim 87 (Original): The method according to Claim 86, wherein the inducing turbulence step further comprises providing a protrusion extending inwardly into the flow passage.

Claim 88 (Canceled)

Claim 89 (Currently Amended): ~~The generator according to Claim 88,~~
~~wherein~~ An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit;

a member having an orifice formed therethrough, fluid flow
through the fluid conduit also flowing through the orifice, and the
member vibrating in response to fluid flow through the orifice; and

a piezoelectric material disposed proximate the member, the
piezoelectric material producing electricity in response to vibration of the
member,

the piezoelectric material is being disposed in a recess formed
internally on the fluid conduit.

Claim 90 (Original): The generator according to Claim 89, wherein a
portion of the member extends into the recess.

Claim 91 (Original): The generator according to Claim 90, wherein the
piezoelectric material is positioned between the portion of the member
and the fluid conduit in the recess.

Claim 92 (Currently Amended): ~~The generator according to Claim 88~~
~~wherein~~ An electrical power generator for use in conjunction with a
subterranean well, the generator comprising:

a fluid conduit;

a member having an orifice formed therethrough, fluid flow through the fluid conduit also flowing through the orifice, and the member vibrating in response to fluid flow through the orifice;

a piezoelectric material disposed proximate the member, the piezoelectric material producing electricity in response to vibration of the member; and

a structure inducing turbulence in fluid flow through the fluid conduit.

Claim 93 (Original): The generator according to Claim 92, wherein the structure extends generally transversely to a flow passage formed through the fluid conduit.

Claim 94 (Canceled)

Claim 95 (Currently Amended): ~~The method according to Claim 94, further comprising the step of~~ A method of producing power in a subterranean well, the method comprising the steps of:

interconnecting in a tubular string a power generator including a member having an orifice formed therethrough;

positioning the tubular string in the subterranean well;

flowing fluid through the orifice;

vibrating the member in response to the flowing fluid step;

producing electricity from a piezoelectric material in response to the member vibrating step; and

inducing turbulence in fluid flowing through the orifice.

Claim 96 (Original): The method according to Claim 95, wherein the inducing turbulence step further comprises positioning a structure in the fluid conduit upstream of the member.

Claim 97 (Original): The method according to Claim 96, wherein the positioning step further comprises positioning the structure so that it extends generally transversely relative to a flow passage formed through the fluid conduit.

Claim 98 (Original): An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

- a fluid conduit;

- a member disposed within the fluid conduit, the member displacing within the fluid conduit in response to fluid flow through the fluid conduit;

- a retainer preventing displacement of the member out of the fluid conduit; and

- a piezoelectric material producing electricity in response to displacement of the member.

Claim 99 (Original): The generator according to Claim 98, wherein the piezoelectric material is disposed between the member and the fluid conduit.

Claim 100 (Original): The generator according to Claim 99, wherein the piezoelectric material supports the member within the fluid conduit.

Claim 101 (Original): The generator according to Claim 98, wherein the piezoelectric material is disposed between the retainer and the fluid conduit.

Claim 102 (Original): The generator according to Claim 101, wherein the piezoelectric material supports the retainer.

Claim 103 (Original): The generator according to Claim 98, wherein the member contacts the retainer in response to fluid flow through the fluid conduit, the piezoelectric material producing electricity in response to such contact.

Claim 104 (Original): A method of producing power in a subterranean well, the method comprising the steps of:

- interconnecting a fluid conduit in a tubular string;
- positioning the tubular string in the subterranean well;
- flowing fluid through the fluid conduit;
- displacing a member within the fluid conduit in response to the flowing fluid step; and
- producing electricity from a piezoelectric material in response to the member displacing step.

Claim 105 (Original): The method according to Claim 104, wherein in the member displacing step, the member is prevented from displacing out of the fluid conduit by a retainer.

Claim 106 (Original): The method according to Claim 105, wherein the member displacing step further comprises contacting the retainer with the member, and wherein in the producing electricity step, the piezoelectric material produces electricity in response to the member contacting the retainer.

Claim 107 (Original): The method according to Claim 105, further comprising the step of supporting the retainer utilizing the piezoelectric material.

Claim 108 (Original): The method according to Claim 104, further comprising the step of supporting the member in the fluid conduit utilizing the piezoelectric material.

Claim 109 (Previously Amended): An electrical power generator for use in conjunction with a subterranean well, the generator comprising:

a fluid conduit having a flow passage formed therethrough and a cavity;;

a membrane separating the flow passage from the cavity, the membrane flexing in response to pressure fluctuations in the flow passage, the cavity being generally annularly shaped and outwardly surrounding the membrane; and

a piezoelectric material disposed within the cavity, the piezoelectric material producing electricity in response to the membrane flexing.

Claim 110 (Original): The generator according to Claim 109, wherein the pressure fluctuations are due to fluid flow through the flow passage.

Claim 111 (Original): The generator according to Claim 109, wherein the membrane is generally tubular.

Claim 112 (Original): The generator according to Claim 109, wherein the membrane sealingly isolates the cavity from the flow passage.

Claim 113 (Original): The generator according to Claim 112, wherein the cavity is at atmospheric pressure.

Claim 114 (Canceled)

Claim 115 (Previously Amended): The generator according to Claim 109, wherein the piezoelectric material is generally annular shaped and outwardly surrounds the membrane.

Claim 116 (Original): A method of producing power in a subterranean well, the method comprising the steps of:

- interconnecting a fluid conduit in a tubular string;
- positioning the tubular string in the subterranean well;
- flowing fluid through a flow passage of the fluid conduit;
- flexing a membrane separating the flow passage from a cavity of the fluid conduit in response to the flowing fluid step; and
- producing electricity from a piezoelectric material in response to the membrane flexing step.

Claim 117 (Original): The method according to Claim 116, wherein in the membrane flexing step, the membrane is generally tubular.

Claim 118 (Original): The method according to Claim 116, wherein the flowing fluid step further comprises flowing fluid through the membrane.

Claim 119 (Original): The method according to Claim 116, further comprising the step of sealingly isolating the flow passage from the cavity utilizing the membrane.

Claim 120 (Original): The method according to Claim 116, wherein in the membrane flexing step, the cavity is at a reduced pressure relative to the flow passage.

Claim 121 (Original): The method according to Claim 120, wherein in the membrane flexing step, the cavity is at atmospheric pressure.

Claim 122 (Original): The method according to Claim 116, wherein in the membrane flexing step, the cavity outwardly surrounds the membrane.

Claim 123 (Original): The method according to Claim 116, wherein in the producing electricity step, the piezoelectric material outwardly surrounds the membrane.